Redesign of High-Power Transmitter Control and Indicator Cards

J. R. Paluka
R.F. Systems Development Section

S. F. Moore
Resdel Engineering
Arcadia, California

The control and indicator printed circuit cards used in the DSN high-power transmitter and the high-power X-band radar transmitter have been redesigned to incorporate short-circuit protection into their outputs. This redesign will increase the overall reliability of these transmitters by eliminating transistor burnouts resulting from shorted interconnection lines, inadvertent shorts while troubleshooting, and other overloads.

I. Introduction

The high-power transmitter was installed at DSS 14 in 1969. A review of its faults since that time has indicated a large percentage to be circuit card failures resulting from overloaded output transistors. Some of these overloads resulted from shorts in interconnection cables that are up to 600 m in length; others have resulted from inadvertent shorts across control or indicator circuits while performing subsystem maintenance. In most cases the result was the same: burned-out transistors and card failure.

With the installation of new high-power transmitters at DSS 43 and DSS 63 during 1974 and 1975, it was resolved to correct this overload problem by redesigning the control logic, metering, and other indicator circuit cards. It was also resolved to preserve the individual circuit card dimensions and connector interface so that the new cards could be retrofitted into the DSS 14 transmitter with no wiring changes.

II. Development

Of the seven types of printed circuit cards in the transmitter controls requiring protection, the most representative of the problem was the lamp/relay driver card. Accordingly, this card was selected for use in the initial development work with a goal of applying similar short-circuit protection to the other types of cards in the controls.

The old lamp/relay driver card provided five independent signal channels, each having a set of complementary outputs. An additional goal of putting seven such channels on each card, to allow for future expansion of the transmitter to an X-band radar, was also made. As with the old cards, each channel was required to provide a minimum of 300 mA of steady-state current.

Additional problems existed in the case of the lamp/relay driver card. One such problem is that each channel may have to drive up to four parallel incandescent indicator lamps. Such lamps have a cold resistance in the order of six to eight times less than their normal hot resistance. Thus, while providing semiconductor protection when the circuit was shorted to ground, the circuit should not be prevented from working when presented with a cold resistance load typically requiring 1.3 A for only 50 ms before dropping to a nominal value of 160 mA. A similar requirement was put on the lamp/relay driver output circuit when required to drive the solenoids of the interlock event recorders. The choice of a current limiter circuit for this card was restricted further by space and the requirement that the entire channel develop a minimum of 25-V output at 300 mA from a supply voltage of 28 V.

As indicated in Fig. 1, a schematic of one of the seven channels of the new lamp/relay driver card, the solution to the current limiter problem was a three-terminal regulator. This is a device that limits the current to approximately 2-A peak current while providing a steady-state current of 500 mA. Since this device is protected by an internal thermal shut-down circuit, it is mounted without a heat sink, thus using the internal heat it produces to protect the circuit. A drawback of this device is that the maximum available output is 24 V; however by biasing the ground terminal to three volts, the regulator will be full on and provide 26.5 V.

When the regulator is overloaded because of a short or other reason, it reduces its output voltage to a safe value. This is accomplished by internal current limiting and by thermal shutdown. This reduction in output voltage increases the voltage across the regulator, turning on the light emitting diode (LED) across the regulator and indicating which channel has an overload fault. The seven LEDs for the entire board are located in a row near the printed circuit card handle where they are clearly visible to the operator when the board is in service. Upon removal of the fault, the circuit returns itself to normal operation and the LED is extinguished.

To gain space and decrease parts count an integrated circuit was chosen for an input device. The LM2900 was selected because it will operate at +28 V on a single supply. This operational amplifier (known as a Norton amplifier) is a type that differentiates between input currents rather than input voltages. Although no advantage was gained by this feature, it provided the necessary open loop gain and, more importantly, the output current sink is sufficient to keep the output transistors (2N5783) always saturated, thus reducing the power dissipated in them to a safe value.

Because the IC selected contains four differential amplifiers, two amplifiers per IC were used to produce the set of complementary outputs required for each signal channel. The point at which the amplifiers switch is selected by the value of resistor dividers R3 and R4. This selection point is a low-impedance point relative to the input resistors R5 and R8. This makes selection of the switching point an easy matter when the circuit is used in other applications.

The normal process for an operational amplifier is to use a feedback resistor to set the gain of the amplifier. This was dispensed with because the amplifier was to have as high a gain as possible. An additional resistor per channel was saved by not having a "pull-up" resistor to keep the output transistors off. These are not needed because the emitter-base is back-biased by the input driver amplifier. The transistor back-bias results from the voltage difference produced by the current limiter.

The 1N649 diode in each output is to prevent high currents that result from the inductive kick of relay coils in the loads destroying the output transistors, and to protect the circuit when connected to a voltage higher than +28 V.

III. Conclusion

A prototype of the new lamp/relay driver card was built and successfully tested in the DSS 14 high-power transmitter. The protective circuit developed for this card was subsequently applied to the summing logic, final logic, warning circuit, bistable on-off, and deenergize delay printed circuit cards. The seventh type of card requiring short-circuit protection was the meter driver. Since other extensive development work had to be performed on this board to provide two meter channels and to provide variable gain for different applications, it was decided to provide the required short-circuit protection by selection of an integrated circuit having inherent protection. Such a device is adequate for this circuit since large output power is not required. As indicated in Fig. 2, a single 747 was selected to provide two meter channels.

Acknowledgment is made for the assistance of Resdel Engineering Corporation of Arcadia, California, particularly Mr. S. F. Moore, for much of the circuit development portion of this undertaking.

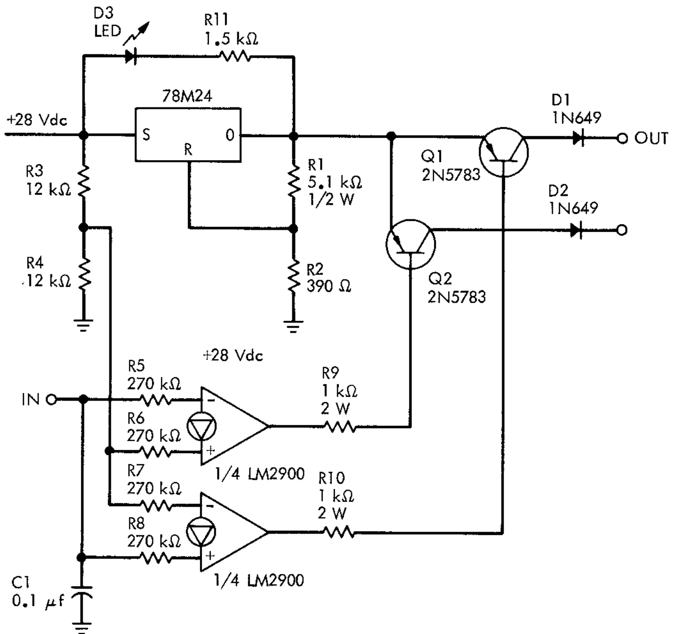

Fig. 1. Schematic, single channel of lamp/relay driver card

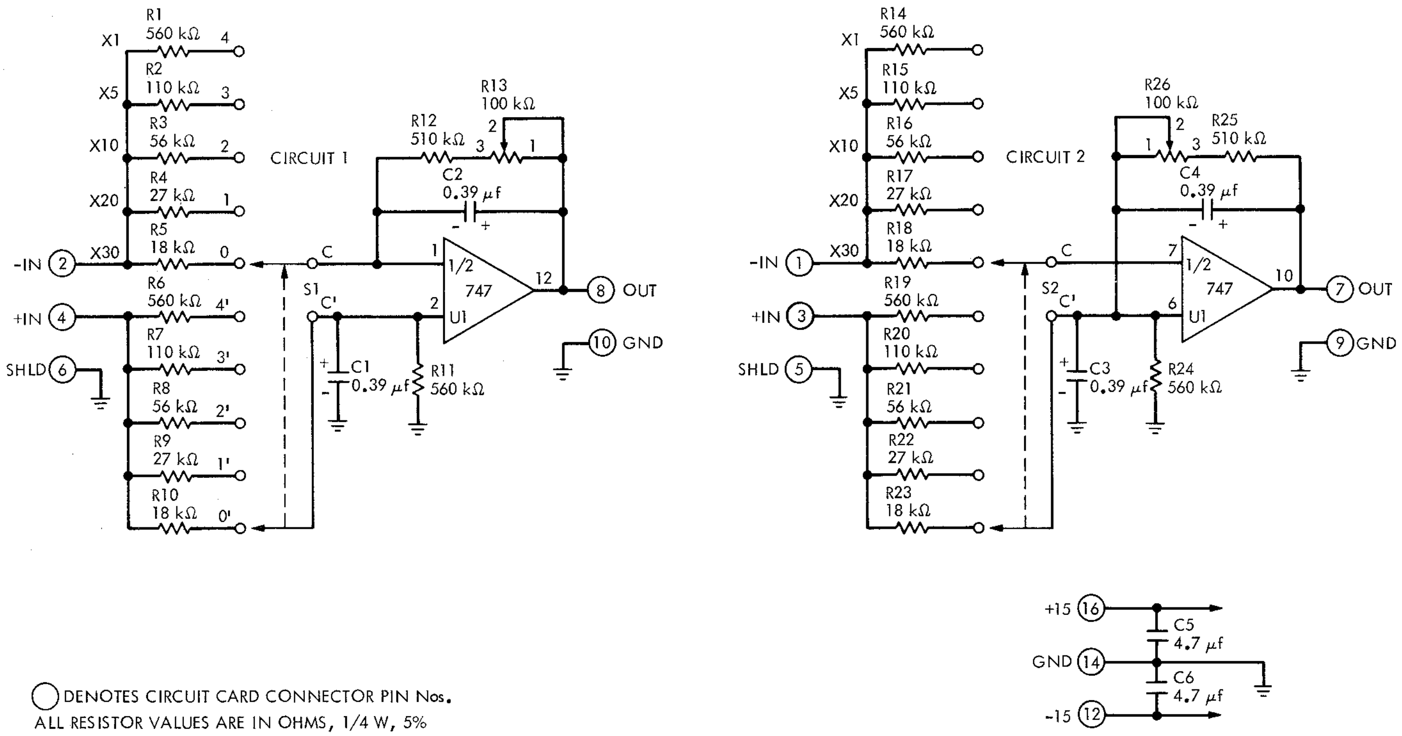

Fig. 2. Schematic, meter driver circuit